

Unclass

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# **NASA BATTERY PROGRAM ANNUAL REVIEW**

***Presentation to Mr. George Rodney***

***AA, Code Q, NASA/HQ***

***March 17, 1988***

**Norman R. Schulze  
NASA Headquarters  
Washington, D.C. 20546**

***NASA Battery Steering Committee***

# **AGENDA**

- **Program Summary**
- **Overview**
- **Current Program Plan**
- **NiCd Problem Discussions**
- **Near and Long Term Solutions**
- **Battery Program Augmentations**
- **Conclusions**
- **Recommendations**

# PROGRAM SUMMARY

- **Purpose today**
  - Status report
  - Code Q approval
    - Dedicated manufacturing NiCd line
    - Program augmentations
- **Results from 1987 Annual Review - Pursue**
  - Super NiCd
  - NiH2
- **Problem Area**
  - NASA Standard
  - Action Plan developed
- **Events**
  - 2 committee meetings
  - NiCd Subcommittee (major thrust)
  - Standard Specification
  - HST Review
  - Workshop
  - Commenced Super NiCd & NiH2
- **Battery Program Plan**
  - Keep documentation current
  - Q concurrence
- **Close involvement of Air Force (Aerospace) - Very supportive**
- **Excellent teamwork & cooperation among NASA centers**

# OVERVIEW

- **Balanced program**
- **Program on schedule**
- **NASA standard NiCd situation - critical**
- **Advanced NiCd production options being pursued**
- **Solutions Identified**
- **Funding augmentation required in FY89 budget**
  - Manufacturing resolution
  - New tasks

## **CURRENT PROGRAM PLAN**

- **Emphasis on improved reliability of energy storage space power systems by providing:**
  - Reliability & QA Issues      Training/Guidelines
  - Documentation      Open Communication Lines
- **Addresses:**
  - Advanced NiCd      NiCd manufacturing resolution
  - NiH2      Primary batteries
- **Expanded activities in critical areas:**
  - Applied Technology for the NiCd and NiH2 systems
  - Addressing short term problems

# ACCOMPLISHMENTS

## SECONDARY

- **NiCd Cells**

- Standard cell enhancement

- Database established
  - Chemical analysis plan prepared
  - Modelling contract awarded

- Advanced concept cells

- Contacts with EP/HAC
  - Advanced technology cells on order
  - Test plan agreement
  - Solution options defined

- **NiH2 technology**

- Extended testing of new design
  - Life testing of advanced technology cells initiated

- **Testing & documentation**

- Computer hardware enhancement in place
  - NiCd cell specification: final approval
  - NASA standard MCD: draft received

## **ACCOMPLISHMENTS Cont.**

### **PRIMARY**

- JSC/JPL development standard LiSOC12 cells
- Draft of user handbook complete

### **SYSTEM**

- Battery workshop held
- FY89 workshop reformatted
- PRACA system being evaluated
- HST power system review completed
- White paper on future battery requirement - draft complete

## **NICD PROBLEM - CRITICAL**

- **Problem Summary**
- **Documented Failures/Anomalies**
  - Known failures
  - Characteristics
- **Near Term Solutions**
  - Completed
  - Plans
- **Long Term Solutions**
  - Dedicated manufacturing facility
  - Augmented program tasks



## **PROBLEM SUMMARY**

- **Ground test failures observed throughout industry since 1983**
- **Flight qualified cells for NASA suspect**
  - Separator change
  - manufacturing changes
- **AF data confirms NASA data**
- **Crane lifecycle testing suggest manufacturing problem**
- **Gates will identify unacceptable lots**
- **Unable to assess impact/extent of problem**

## **PROBLEM SUMMARY Cont.**

- Potentially affects the following NASA programs:

NOAA  
TDRSS  
COBE  
MGN  
GRO  
TOPEX  
GOES  
MO  
UARS  
MM II  
AXAF  
Explorer Platform  
SIRTF

## **DOCUMENTED FAILURES/ANOMALIES**

- **Known failures in ground test**
  - GSFC separator requalification program
  - GSFC COBE 50AH lot verification test pack
  - GE Astro TIROS/NOAA flight lot 14 (separator test) and test battery lot 15
  - AF separator requalification program
  - Martin-Marietta test battery program

## **DOCUMENTED FAILURES/ANOMALIES Cont.**

- **Characteristics of anomalies and failures**

- Rigorous NASA standard acceptance test requirements at manufacturer provide no indication of this problem
- Divergence of voltage response among cells initially well matched
- Loss of capacity and low end-of-discharge voltage
- Internal cell shorting
- Problems begin to occur after approximately 1 year in LEO or 4 shadows in GEO

## **DOCUMENTED FAILURES/ANOMALIES Cont.**

- **Investigation of probable cause currently underway**
  - Cells from each program are undergoing DPA
  - Cell vendor (Gates) conducting analysis of cells
  - Informal communication within the aerospace battery community
  - Cell vendor will present findings to NASA and AF by mid-April
- **Preliminary indications from DPA data**
  - Excessive cadmium migration into separator
  - Large increase in negative electrode precharge
  - Premature breakdown of separator
- **Possible generic manufacturing line problem**

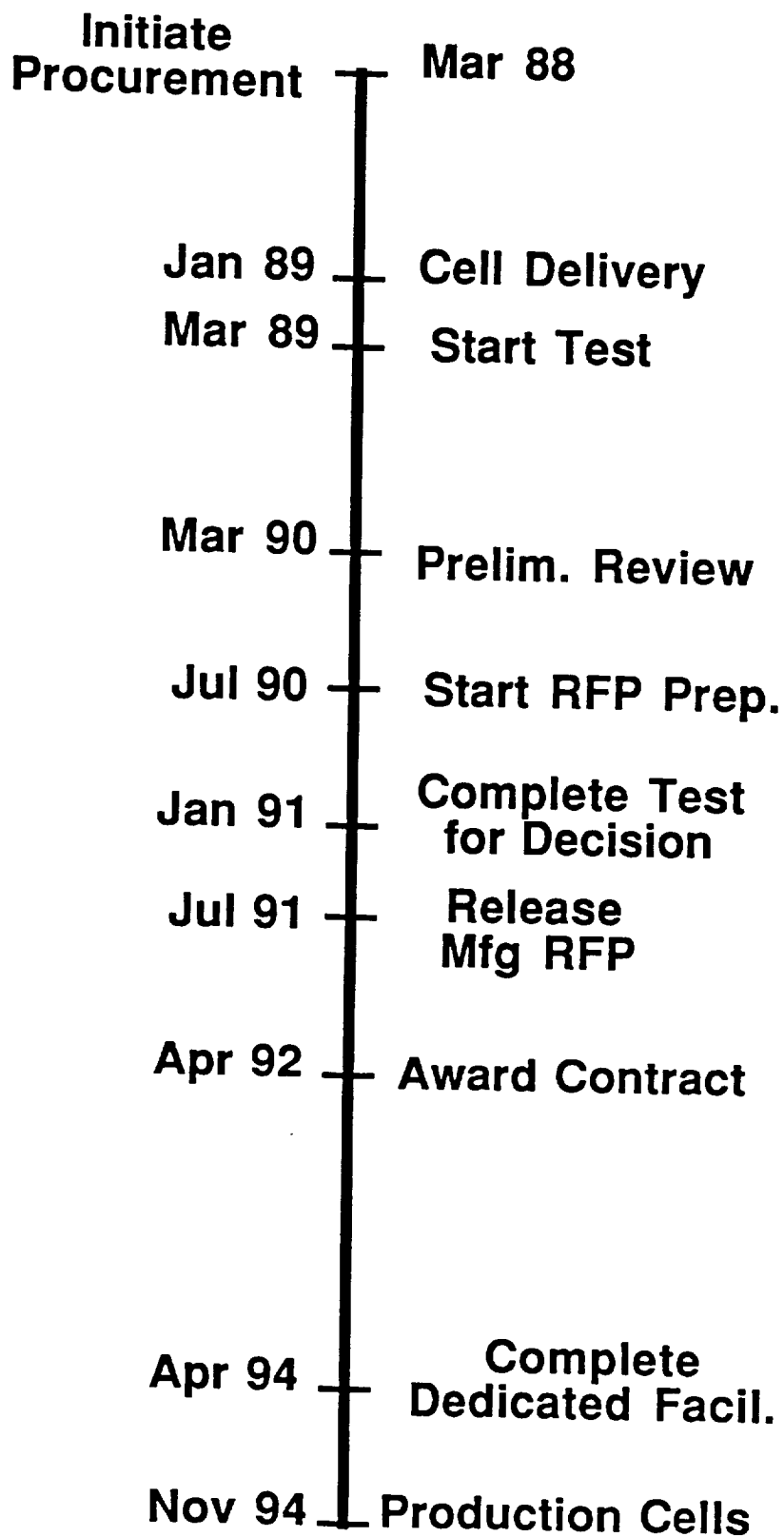
## NEAR TERM SOLUTIONS

- **Completed**
  - Code Q letter to Codes E & T
  - Contacts with Gates / letter to Gates President
  - Chemical analyses (DPA) by Gates
  - Interaction with battery community "AF/Commercial"
- **Near Term Solution Plans**
  - Hold technical meeting with Gates
  - Assist Gates with solutions
  - Plan to test advanced technology cells
  - Implement/continue flight project cell test
  - Develop advanced electrochemical diagnostic and design techniques
  - Present Gates findings to NASA/AF mid-April
  - Evaluate SAFT/France aerospace cells

## **LONG TERM SOLUTIONS**

- **Dedicated manufacturing facility: Advanced NiCd**
  - **OPTION #1**  
Set up a semi-dedicated manufacturing line at EP-CS or Gates, instituting dedicated equipment where deemed necessary
  - **OPTION #2**  
Set up a fully dedicated manufacturing facility at EP-CS or Gates
  - **OPTION #3**  
Set up a fully dedicated, government-owned manufacturing facility, operated by a contractor

**DEDICATED ADVANCED NICD MANUFACTURING PLANS**





## LONG TERM SOLUTIONS Cont.

- **Approach**

- Continue review of successful GEO/boilerplate LEO data/HAC
- Procure advanced technology cells from EP/CS
- Initiate feasibility discussions with EP/HAC
- Evaluate preliminary cost estimates & approach (option 1)
- Consider other manufacturers
- Plan competitive procurement
- Discuss possible interaction with Gates in April
- Hold preliminary discussion with SAFT in March

- **Cost**

-	Option 1 - \$5M required	FY90 - 1.00M FY91 - 2.50M FY92 - 1.50M	
-	Option 2 - Non Recur (Total) Recur (Annual)	7.25M < 9.50M	
-	Option 3- Non Recur (Total) Recur (Annual)	9.00M < 9.50M	(High)

## **BATTERY PROGRAM AUGMENTATION for NICD**

- 1) Establish interactive manufacturing technology transfer program to better understand process variables and improve product quality**
- 2) Develop use of complex impedance as an electrode evaluation technique**
- 3) Establish analytical/electrochemical test facility to provide timely, reliable, accurate analyses**
- 4) Establish Non-destructive evaluation capability to provide methods for determining quality without disassembling**
- 5) Expand capability for cell performance characterization to provide greater flexibility in more timely manner**
- 6) Procure advanced technology cells from Gates as a dedicated manufacturer competitor**

## **BATTERY PROGRAM AUGMENTATION FOR NiH2**

- 7) Establish the effect of hydrogen embrittlement on NiH2 pressure vessels**
- 8) Establish the effect of charge control methods on performance and life**
- 9) Establish specification and MCD for standard NiH2**

# BATTERY PROGRAM AUGMENTATION FOR NICD

## COST BREAKDOWN

	<u>FY89</u>	<u>FY90</u>	<u>FY91</u>	<u>FY92</u>
1) Mfg Tech Transfer	200	200	100	
2) Complex Impedance	100	100		
3) Analytical Facility	200	100	100	100
4) Establish NDE Capability	200	200	100	
5) Expand Test Capability	250	200	100	100
6) Procure Gates Cells	250			
	<hr/>			
Sub Total NiCd	1200	800	400	200

**BATTERY PROGRAM AUGMENTATION FOR NIH2**

**COST BREAKDOWN**

	<u>FY89</u>	<u>FY90</u>	<u>FY91</u>	<u>FY92</u>
7) H2 Embrittlement	100			
8) Charge Control Methods	100	100		
9) MCD & Specification	50	50		
	<hr/>			
Sub Total NIH2	250	150		

# RESOURCE SUMMARY

## COST BREAKDOWN

	<u>FY89</u>	<u>FY90</u>	<u>FY91</u>	<u>FY92</u>
Augmentation Tasks - NiCd	1200	800	400	200
Augmentation Tasks - NiH2	250	150		
<u>Dedicated Option #1</u>		1000	2500	1500
<u>Total Augmentation</u>	1450	1950	2900	1700
Approved Plan	1500	1500	1200	1200

## **CONCLUSIONS**

- **Augmentations required to help solve critical NASA battery problems**
- **Near term issues being addressed**
- **Long term solutions necessary to prevent flight program impacts**
  - Dedicated facility
  - 6 NiCd tasks
  - 3 NiH2 tasks
- **Seeking your approval for FY89 start**

## **RECOMMENDATIONS**

- **Concurrence with the plan contents**
- **Support and funding to resolve per the plan**



## **NASA-AEROSPACE/AFSD COOPERATION ON SPACE BATTERIES AREAS OF MUTUAL INTEREST**

- **NICD Cells**
  - Quality of presently manufactured cells
  - Advanced NiCd cell
- **NiH2 Cells and Batteries**
  - Application to LEO missions
  - Battery management strategies
  - Advanced NiH2 cell
- **Primary (Non-rechargeable) Batteries**
  - Advanced cells
  - Safety
- **Cell analysis capability at government related facility**

## **NASA-AEROSPACE/AFSD COOPERATION ON SPACE BATTERIES NICD BATTERIES**

- **Quality of presently manufactured cells**
  - Exchange build and test data
  - Joint meeting with Gates
  - Joint meeting with SAFT
  - Complementary plans for future tests
- **Advanced NiCd Cell**
  - Joint meetings with Hughes and Eagle-Picher
  - Complementary plans for tests and quality assurance programs
  - Exchange future build and test data
- **Support establishment of cell analysis facility**
  - To be used by NASA and AFSD programs
- **Exchange of research expertise**
  - Key processes in NiCd cells
  - Evaluations of accelerated testing

## **NASA-AEROSPACE/AFSD COOPERATION ON SPACE BATTERIES NIH2 BATTERIES**

- **Application to LEO Missions**
  - Exchange test data
  - Initiate program specific NASA test
- **Battery management strategies**
  - Exchange research results
  - Exchange test data
- **Advanced NIH2 cell**
  - Exchange research results
  - Exchange test data
- **Support establishment of cell analysis facility**

# EVALUATION OF SAFT NICKEL CELLS

- **Purpose**

Evaluate SAFT aerospace NiCd cells to establish a database and to study the feasibility of using it

- **Justification**

- With the current manufacturing problems at Gates, SAFT may be an alternate source for NiCd
- SAFT supplies NiCd cells to ESA and many commercial European flight programs
- NASA needs to be aware of existing aerospace NiCd technology via testing and establishing corresponding database

## **APPROVAL/QUALIFICATION OF SEPARATOR**

- Previously qualified Pellon 2505 material discontinued in 1976
  - Pellon 2536 material to be the replacement material used by Gates
  - Qualification program initiated in 1985 at GSFC, AF, and various prime contractor facilities
    - Anomalies/failures unrelated to separator precluded 2536 approval
- Pellon 2505 supplies have run out; Gates must use Pellon 2536
- Current NASA flight projects will have Pellon 2505 separator material with the exception of UARS, Explorer platforms, GOES, Mars Observer, and TOPEX

10/88

# NASA AEROSPACE BATTERY PROGRAM PLAN PROPOSED BUDGET FOR FY89

TASKS  
FY88  
FY89  
EST ALLOC ACTUAL EST SUGG ALLOC

## 6.1.0 PROGRAM MANAGEMENT

6.1.1	Program Support	20	0	5	20	10
6.1.2	Travel Support	10	0	0	10	10

### Subtotal

30	0	5	30	30
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## 6.2.0 BATTERY SYSTEMS

6.2.1	Battery Systems NHB	30	25	25	0	20
6.2.2	Battery Safety NHB	0	0	0	0	0
6.2.3	Training Program	85	0	0	60	85
6.2.4	Problem Reporting System	10	23	25	10	15
6.2.5	Battery Workshop	10	16	16	10	16
6.2.6	Program Requirements	10	10	8	10	10

### Subtotal

145	74	74	90	146
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## 6.3.0 SECONDARY BATTERY PROGRAM

6.3.1	Verification of Secondary Cells	300	150	178	650	250
6.3.2	Procurement Evaluation	25	25	0	0	25
6.3.3	Long Term Resolution of Ni-Cd Problems	0	25	25	0	0
6.3.4	Applied Ni-Cd Technology	300	400	400	300	300 *
6.3.5	Power Systems Review	0	40	40	0	0
6.3.6	Ni-H2 Technology	0	95	95	0	250
6.3.6	Test Facility Support	90	91	91	90	91

### Subtotal

715	826	829	1040	916
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## 6.4.0 PRIMARY BATTERY PROGRAM

6.4.1	Primary Battery NHB	30	0	0	20	20
6.4.2	Space Qual. Primary Cell	80	80	0	50	80
6.4.3	NASA Primary	200	220	220	300	250

### Subtotal

310	300	220	370	350
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## PROGRAM SUBTOTAL

1200	1200	1200	1530	1442
0	0	72	0	57
1200	1200	1200	1530	1499

## TOTALS

## UNALLOCATED

0

\*JPL requested 350 K for FY89 in their revised task plan for  
Flight Batteries - Applied Technology" dated March 8, 1988

NASA AEROSPACE BATTERY PROGRAM PLAN  
PROPOSED BUDGET FOR FY89  
10/88

TASKS  
FY88 EST ALLOC ACTUAL  
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6.1.0 PROGRAM MANAGEMENT

6.1.1	Program Support	20	0	0	5	20	10
6.1.2	Travel Support	10	0	0	0	20	10
Subtotal		30	0	0	5	30	30

6.2.0 BATTERY SYSTEMS

6.2.1	Battery Systems NHB	30	25	25	25	0	20
6.2.2	Battery Safety NHB	0	0	0	0	0	0
6.2.3	Training Program	85	0	0	0	60	85
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6.3.1	Verification of	300	150	178	178	650	250
6.3.2	Secondary Cells	25	25	0	0	0	25
6.3.3	Long Term Resolution	0	25	25	25	0	25
6.3.4	of Ni-Cd Problems	0	25	25	25	0	0
6.3.4	Applied Ni-Cd Technology	300	400	400	400	300	300 *
6.3.5	Power Systems Review	0	40	40	40	0	0
6.3.5	Ni-H2 Technology	0	95	95	95	0	250
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6.4.1	Primary Battery NHB	30	0	0	0	20	20
6.4.2	Space Qual. Primary Cell	80	80	80	80	50	80
6.4.3	NASA Primary	200	220	220	220	300	250
Subtotal		310	300	220	220	370	350

PROGRAM SUBTOTAL  
TAX  
TOTALS

1200	1200	1128	1530	1442
0	0	72	0	57
1200	1200	1200	1530	1499

UNALLOCATED

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NASA AEROSPACE BATTERY PROGRAM PLAN  
10/88

PROPOSED BUDGET FOR FY89

TASKS  
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6.1.1	Program Support	20	0	5	20	10	20	10	
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6.2.4	Problem Reporting System	10	23	25	10	10	15	15	
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6.3.3	Long Term Resolution	0	25	25	0	0	0	0	
6.3.4	Applied Ni-Cd Problems	300	400	400	300	0	300	300	*
6.3.5	Power Systems Review	0	40	40	0	0	0	0	
6.3.6	Ni-H2 Technology	0	95	95	0	250	0	91	
	Test Facility Support	90	91	91	1040	916	916	916	
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PROGRAM SUBTOTAL	1200	1200	1128	1530	1442				
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\*JPL requested 350 K for FY89 in their revised task plan for Flight Batteries - Applied Technology" dated March 8, 1988



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	Subtotal	30	0	0	5	20	30	20	30

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6.2.3	Training Program	85	0	0	0	10	60	15	85
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6.3.3	Long Term Resolution of Ni-Cd Problems	Pending	Study Results	25	25	0	0	0	0
6.3.4	Applied Ni-Cd Technology	300	400	400	400	300	300	300	300 *
6.3.5	Power Systems Review	0	40	40	40	0	0	0	0
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	TAX	0	0	72	72	0	57	57	57
	TOTALS	1200	1200	1200	1200	1530	1499	1499	1499
	UNALLOCATED	0	0	0	0	0	0	0	0

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# REPORT DOCUMENTATION PAGE

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6. AUTHOR(S) Norman R. Schulze and NASA Aerospace Battery Systems Steering Committee					
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Office of Safety and Mission Quality Code Q NASA Headquarters Washington, D.C. 20546				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of Safety and Mission Quality Code Q NASA Headquarters Washington, D.C. 20546				10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES					
12a. DISTRIBUTION / AVAILABILITY STATEMENT Batteries, electrochemistry, secondary cells, primary cells. spacecraft systems, electrical power systems				12b. DISTRIBUTION CODE Unlimited	
13. ABSTRACT (Maximum 700 words) The first NASA applied technology program was initiated by the author to address problems being experienced by a mature aerospace technology, in this case battery system/electrochemistry technology, with a goal to enhance program reliability. In May 1985 battery issues were discussed by Dr. Halpert (JPL), and a program to resolve those issues was presented by the author to the NASA Administrator who authorized both the battery program and the establishment of the battery steering committee. Thus, to assist with the implementation of this unique NASA applications-oriented technology program and to facilitate communications among the agency's battery technologists, the author established the NASA Battery Systems Steering Committee which was comprised of battery experts from each of the NASA centers, plus the Air Force (space systems). This report presents that program's results for the first funded year, to the Code Q Associate Administrator for Safety, Reliability and Quality, the funding office. The three basic program elements consisted of: primary cells, secondary cells, and battery systems. The program has short and long terms activities. The secondary (nickel-cadmium) cells were the most critical energy storage problem that NASA needed to address, and, to that end, the most profound project proposed was the establishment of a dedicated aerospace secondary cell manufacturing line to resolve that issue. The program results, status, and recommendations were accepted. A budget is also included. The Associate Administrator requested a review of the serious nickel-cadmium cell concerns threatening many programs.					
14. SUBJECT TERMS				15. NUMBER OF PAGES	
				16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified		18. SECURITY CLASSIFICATION OF THIS PAGE		19. SECURITY CLASSIFICATION OF ABSTRACT	
				20. LIMITATION OF ABSTRACT	